1995

Obstacles to achieving quality in construction and improvement methods

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OBSTACLES TO ACHIEVING QUALITY IN CONSTRUCTION AND IMPROVEMENT METHODS

A Thesis

Presented to

The Office of Graduate Studies,

the Faculty of the College of Business

and the Division of Technology

San Jose State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

Quality Assurance Management and Engineering

by

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December, 1995

UMI Number: 1377243

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ABSTRACT

Obstacles to Achieving Quality in Construction

and Improvement Methods

By Timothy R. Kirsch

Total Quality Management is being increasingly implemented in the construction industry with varying success. An underlying theme in Total Quality Management is that a quality focus will reduce rework by increasing productivity through efficiency. The premise of this research is that there exist a number of obstacles to quality which when removed will increase productivity. The researcher, by surveying construction inspectors throughout the Bay Area, suggests which are the most common inhibiting factors to quality in the construction industry and how trades' conformance to requirements may differ. Training and management direction consistently rank as the most important factors influencing quality. In addition, electricians score higher than other trades when examining their conformance to code requirements and job specifications.

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CHAPTER ONE

Introduction

Background

Immediately following the 1991 Northridge earthquake, inspections of the damaged buildings clearly indicated that some failures could be attributed to worker error and non-conformance to building codes and specifications (ENR, 1994). These revelations become even more disturbing when one considers that Southern California has some of the most stringent construction regulations and enforcement practices in the country. The Northridge earthquake provides an example of how quality issues in the construction industry comprise a significant problem which affects human lives and property. In retrospect, the importance of construction quality can be emphasized, but it is more difficult to determine why inferior quality occurred.

One way the construction industry currently addresses quality issues is by implementing Total Quality Management (TQM) in design and building processes. In addition, principles of TQM are being used in every possible facet of manufacturing, service, and consulting industries to increase productivity and motivate individuals (Rothman, 1994). TQM has become a popular catch-phrase in all business fields during the 1990s, since it assists in understanding why worker quality problems occur.

Even though there is a great amount of research on TQM, there is a lack of research specific to the construction industry, and expert theories, while widely accepted, are based upon assumptions which have not been entirely investigated.

The construction industry is unique in that companies often provide both a product and a service simultaneously. For example, an owner may hire one company to design, manage, and construct a project. In this case TQM principles can be applied to engineering tasks as well as construction services while total processes can be examined within a system framework.

As with any skill-based production industry, workers are arguably the most important ingredient in construction processes. Through their actions, tradesmen determine whether quality will be achieved, and it could be argued that they have the greatest influence on a successful project's critical path. Unfortunately, workers can also create a weak link in the TQM process. Therefore, the worker provides a logical basis for researching quality. Once management realizes how workers specifically affect quality, obstacles within a system can be removed or minimized.

TQM Overview

Experts of TQM, including Deming, Juran and Crosby, present management guidelines for increasing quality. Even though quality management experts might promote different techniques to obtain common objectives, each shares two basic premises of TQM:

first, an organization must work as a system to satisfy customer needs, and second, in order to satisfy customer needs, people must be productive (Wilson, 1994). The first item focuses on establishing, maintaining, and expanding markets for profitability, while the second centers on productivity in order to utilize resources effectively for profitability. These two premises fit well into a construction industry point of view. Just as in any other production-based industry, satisfying customer needs by providing a product and maintaining productivity for profitability are necessary for success.

A basic principle of Total Quality Management is that workers in general want to achieve a high level of performance. Due to human nature and value systems, employees instinctively take pride in their work. Furthermore, workers in diverse fields share common notions of quality and exhibit positive attitudes regarding quality. While these premises of TQM are generally accepted, there has been little study to show their validity.

The objectives of Total Quality Management require organizational leaders and managers to build upon their workers' natural tendency towards quality by empowering employees and omitting obstacles which would increase defects in production. Therefore, before managers can remove the obstacles limiting quality, they must know what the obstacles are.

Objective

This study will concern itself with productivity by focusing on the factors which limit quality by specifically identifying some of the most common inhibiting factors to quality in the construction industry. In order to isolate these factors, conformance to plans, specification, and code requirements in addition to rework issues will be points of reference for study participants. Conformance errors and rework are not only an indication of quality deficiencies, but by definition, an indicator of reduced productivity. Since quality issues are necessary for productivity measurement, it is logical that if there is not quality, there cannot be high productivity. By tracing causes of rework and quality, conclusions concerning productivity can be made and the results will help managers transform organizations in the TQM process. In other words, once management recognizes the weaknesses in the systems and obstacles to quality, it can implement steps for improvement.

The premise of this study is that workers are likely to work to achieve quality. When the quality of a job is not achieved, as defined by project specifications or code requirements, reoccurring reasons which inhibit quality can be defined. There exist both internal and external obstacles; once these obstacles are identified they can be examined by management and ultimately minimized. The identification of obstacles and knowledge of shared quality concepts is important when empowering workers and increasing total quality (Johnson & Kazense, 1993).

Problem Definition

The principles of TQM are closely tied to a few basic theories of workers' behavior and attitudes. While much has been written in many fields about work attitudes, very little research has been conducted on inhibiting factors affecting workers' attainment of quality objectives. Identifying inhibiting factors is important because it assists managers when selecting areas of improvement for increased productivity. Furthermore, knowing the most common obstacles to quality becomes a valuable resources used by managers to empower their work force. Again there are accepted ideas about obstacles, but research does not indicate which are the most common and which have the greatest effect on quality.

Research Questions

From an inspector's perspective, obstacles to quality will be identified and ranked. Quality will be defined from a commonly accepted definition of conformance to plans and specifications. The specific research questions are as follows:

1. What are the most common inhibitors to achieving quality in building construction?
2. What factors have the most influence on achieving quality?
3. Are there differences between different trades and their conformance to plans and specifications?

Limitations of the Study

The greatest limitation of this research is that only inspectors' opinions or attitudes are being examined. Inspectors' perceptions may be different from actual worker behavior, yet perceptions will provide insight for managers and can be indicators of behavioral tendencies. Lastly, knowing which obstacles are most common may not indicate which obstacles have the most impact on customers or costs.

Delimitations

As the limitations explained, this study is not meant to obtain general results that can be applied to all industries. The information contained within will, however, provide a basis for future research in other fields and allow for comparison with other fields.

Definitions of Terms

For the purposes of this study, the following definitions of terms will apply:

Attitude. An evaluative statement concerning objects people or events. An attitude contains behavioral components which refers to an intention to behave in a certain manner (Robbins, 1993).

Efficiency. The ratio of useful output to total input in a system. The effective use of resources to achieve a quality product.

Empowerment. Allowing employees to make informed decisions in the customer's best interest through training, education, and encouragement.

Equipment. The physical tools needed to perform a task.

Error. A deviation from what is correct. A mistake. The difference between a computed, measured, or expected value and the correct value.

Management. A person or group that formulates, implements, and evaluates functional decisions that enable an organization to obtain its objectives.

Production Worker. Any person who converts some type of material into an output.

Productivity. A ratio of outputs of acceptable quality to inputs consumed while utilizing resources efficiently.

Quality. Fitness for use. Satisfying and fulfilling customer needs. Conformance to predetermined specifications.

Rework. Any time a process or action must be repeated or changed to correct a product of inferior quality.

Total Quality Management (TQM). A philosophy and a systematic approach to achieve continuous improvement of quality in order to satisfy customer needs.

Training. The act, process, or routine of coaching, teaching, or making one accustom to a mode of behavior or performance.

Value. "An enduring belief that a specific mode of conduct or end-state is personally or socially preferable to an opposite or converse mode of conduct or end-state of existence" (Rokeach, 1973).

Significance of the study

Deming (Walton, 1986) emphasizes the need for information and knowledge about a process before implementing change. Tampering with a system can add to existing problems. Thus, knowing the most common obstacles to achieving quality can be of great importance to managers. Having information about rework causes can help management make decisions on how to improve productivity and efficiency. In addition, changing common notions about workers being viewed as lazy and unmotivated will assist management in improving their interaction and communication. From an employee's standpoint workers will realize the source of their frustration is not uncommon and that changes can be made to increase satisfaction. In fact, any changes must be in partnership between management and employees.

CHAPTER TWO

Review of the Related Literature

Quality

Achieving quality is a dynamic process. While business activities are often emphasized, quality can be a characteristic of any situation in which a person, either individually or in a group, produces some type of output. Quality management techniques can be practiced both in production and service industries. Since quality is so far reaching and contains diverse meanings, the term must be examined beyond a simple definition.

A commonly accepted definition of quality is the degree of conformance of all the relevant features and characteristics of a product to all of the aspects of a customer's need (Vonderembse, 1988). Implied by "customer's need" are price and delivery considerations. Therefore, a quality product or service is one which meets or exceeds customers' expectations of utility, price, and service.

The above definition at first glance is almost purely taken from a marketing point of view which promotes all business actions undertaken should stem from customer desires. Upon closer examination, it illustrates any type of activity can benefit from quality concepts. For example, in business, every activity from designing, to engineering, to manufacturing, to sales, to logistics has only one purpose: satisfying customer needs. If the customer's needs are not satisfied, then most likely the product or service will fail in the marketplace. Thus, every aspect of creating a product's life cycle should include customer expectations.

To emphasize quality from a customer standpoint, let us examine the following scenario. An engineer may design a product to last for a long period of time, thinking it will have increased quality over the competition whose product has a shorter life cycle. Yet, the product may fail because the engineer does not share the same quality parameters as customers. In the engineer's mind, a competing product may be shoddy and of lesser quality. However, one must realize that quality is determined by the customer. Companies do not go out of business because they produce shoddy merchandise. They go out of business because the merchandise does not satisfy consumer needs. If the customer defines a useful life of one year, then one year becomes the basis for lifetime quality in design and any utility over one year is added value, surpassing customer needs.

Satisfying customer needs is a useful general definition for quality since it can be applied in all areas of business and addresses the heart of business activities. It would be unreasonable to expect ordinary workers to come up with an agreeable academic definition. But they do have common ideas about quality and want to achieve quality, as pointed out by Deming when defining quality through worker, manager, and consumer perspectives:

> In the mind of the production worker, he produces quality if he can take pride in his work. Poor quality, to him, means loss of business, and perhaps his job. Good quality, he thinks, will keep the company in business. . .quality to the plant manager means to get the numbers out and to meet specifications. His job is also, whether he knows it or not, continual improvement of processes and continual improvement of leadership (Mawhinney, 1992, p. 233).

For the purposes of this study, "quality" will have a more specific meaning, since a person can grasp the essence of quality without referring to the customer. Therefore, in addition to meeting customer needs, quality can be defined as conforming to project specifications and building codes. Most people assume, especially in the construction industry, that specifications take into account customer requirements. If quality means "producing according to specifications," then management must ensure that those specifications satisfy customer requirements. For example, if a box requires three nails to hold it together, but four are required by specifications; four nails become the benchmark standard of quality conformance. Therefore, quality does not mean doing only what is sufficient where more is required by project specifications.

Total Quality Management

A study by the American Quality Foundation (AQF), a New York-based think tank, revealed that organizations do not always understand what quality means or how to obtain it (Caurdron, 1993). Of 584 companies surveyed, 495 different quality management techniques were used. The AQF study shows the need for quality is great in today's markets of international competition, technology-based change, and savvy customers. Since quality is a dynamic process which encompasses all areas of an organization, the techniques used to foster quality are contained in Total Quality Management (TQM). TQM's meaning may not be entirely clear because many experts promote diverse techniques and there is disagreement on TQM programs. However, there are similar characteristics which help define TQM.

TQM is viewed most simply as a means to achieve quality. TQM draws upon many different disciplines such as statistics, quality assurance, quality control, human resource management, and empowerment, which together produce productive systems. Furthermore, Total Quality Management addresses many issues such as market share, costs, cycle time, revenues, productivity, and utility. All elements of a process are designed, implemented, and evaluated around customer satisfaction, since the customer is a point of reference for TQM.

There has been a backlash against quality management techniques largely due to implementation failures in American industries (Griffis, 1992). A common complaint is that increasing quality can decrease profitability. Experience shows in order to increase quality, expenditures are needed for improved equipment, training, or at the very least production rates might decrease in allowing for quality control. In fact, quality cannot be increased without changing the status quo which, in most cases, will not be profitable in the short term.

However, true TQM theory promotes just the opposite of common criticisms. When quality is increased through training, design, new equipment, or production changes, profitability will increase in the long run through increased efficiency. Producing for quality in addition to reducing cycle time, increases satisfaction and reduces costs associated with defects. Specific to the construction industry, Chase (1993) recommends investing in quality through training because people are the most valuable asset and means to achieving quality. Chase further states, "If you possess only one unique, valuable asset, an investment in improving the quality and security of that asset is always justified."

Productivity

There exist numerous definitions of productivity whose essence can be summarized as output divided by some input. The equations below depict some of the most common productivity relationships (Maloney, 1990). These equations do not, however, indicate that all productivity definitions rely on an important assumption which must be examined before a complete understanding of productivity can be gained.

$$\text{Productivity} = \frac{\text{Output}}{\text{Labor + Equipment + Materials}}$$

$$\text{Productivity} = \frac{\text{Square feet}}{\text{Dollars}} \qquad \text{Labor Productivity} = \frac{\text{Output}}{\text{Labor Costs}}$$

It is assumed that the amount or type of output is only relevant if it meets determined quality standards. In other words, productivity can only be measured if quality is evaluated. For example, when a worker produces to obtain a final count without regard to quality, then productivity in the long run will suffer since that product will most likely need rework or be a defect. Likewise, productivity can also be examined in the design stage of a product. If an engineer designs to accommodate production limitations and is observant of potential problems in other functional areas, then he is designing with quality in mind. One will be productive because redesigning or future changes can be lessened or eliminated. Furthermore, and perhaps most important, the engineer will address the customer's expectations and desires, thereby producing a quality product.

The above examples show how quality in the long run increases productivity by decreasing redesign and rework. All of these factors will increase profitability and utilize resources efficiently (Johnson & Kazense, 1993). In contrast, rework will cause any short term gains to be lost. The very fact that there is rework indicates that there is a quality problem.

When an item needs rework it takes valuable resources away from other activities and can more than double production costs. Costs associated with rework can be broken down into production personnel, test personnel (higher percentages of rework require more test personnel), component replacement parts, time, space, machines, lost opportunity, and lost profit. Rework signifies quality deficiencies; thus, the odds of undetected quality problems increase when resources are spent on rework instead of improving processes (Walton, 1986). Training is also affected by rework since allocating time for training is difficult when excess time is spent on correcting non-conformances. Most importantly, if a faulty product reaches its customer, then the potential of future lost business must be estimated along with accountable rework expense and warranty costs.

There are two subdivisions to productivity: human factors and technical factors. A person's attitude, training, compensation, and goal-orientation are human factors which affect quality. Human factors interplay with each other to create the work environment. Technical factors are those elements which humans utilize to produce outputs and include machinery, equipment, and information technology (Johnson & Kazense, 1993).

Human factors interact with and react to technical factors and combine with external factors to give quality. The initial step in understanding productivity problems begins with human factors, i.e., the operational people. Operational people are those who implement final designs and directives. They are the most important link between organizational goals and the customer. These people know the process, its limitations, the system, and they make numerous daily decisions affecting quality. Furthermore, because productivity is an indicator of quality, the root of problems can be found at the worker. This is not to say workers cause all deficiencies, but they deal with the factors that cause problems. By examining processes from the worker's perspective, management can examine and correct problems effectively.

If workers are the most important link to quality, then a quality transformation should begin with them. Obstacles which inhibit their work need to be identified and removed. Management's responsibility is to ensure workers are competent, motivated, and have an environment which influences their productivity.

Organizational leadership must realize productivity is related to the laws of supply and demand (Wollner, 1992). Just as in the marketplace when the demand for a product is high, there is an incentive to produce that product. Quality follows the same parallel. If management provides incentives for employees to strive towards quality and gives the opportunity, then the employees will work for it. Most TQM efforts fail because once the incentive is taken away so follows quality. When old incentives that produce business as usual are in still place then a quality management program cannot succeed. Productivity comes down to each person and the person's attitude toward quality. Managers should ask which actions must be taken to produce quality and if there is a great enough incentive to produce quality combined with the existing environment and tools (Roberts, 1993).

System Processes

ISO 8402 defines a quality system as "the organizational structure, responsibilities, procedures, processes and resources for implementing quality management" (ISO, 1992, p.15). The systems approach to organizational analysis is very important to TQM. When quality is the end objective of companies, all areas of an organization should be working towards satisfying customer requirements. Viewing organizations as a system, allows one to examine individual components within the system and the system as a whole. In this way the end objective, quality, is not lost. This study recognizes that humans are part of a system, and they react to and interact with other system components such as the environment, culture, machinery, and technology. It is the process interaction which increases or diminishes quality (Cooper, 1992).

James F. Riley Jr. shows the importance of a systems approach to understanding processes:

> TQM is ..."a transformation in the way an organization manages. It involves focusing management's energy on the continuous improvement of all operations, functions, and above all, processes of work. Quality is really nothing more, therefore, than meeting customer needs. To do this [one] must improve the work processes..."(Cauldron, 1993, p. 29)

Viewing work processes from a systems orientation is a helpful technique used in TQM. The systems point of view basically shows how all elements working together in an organization produce an output. It is an integrative technique linking diverse departments, tasks, and hierarchical levels to show interaction and reaction. A systems approach will indicate the many work processes involved to create an output. Moreover, Snee (1993) emphasizes that a work process is a series of activities performed by people to transform materials and information into an output. Work processes involve people, equipment, procedures, materials, and information, and are influenced by the operating environment. When people perform a series of activities to transform materials and information into an output, they are taking part in a work process. If any one or more of these items is not designed to minimize error then there can be redundancy, errors, and rework.

The key elements within any process are the individual human actions and decisions. One way to examine the way processes within a system are designed is to utilize the idea of "robustness." A process can be considered "robust" if "it is insensitive to uncontrollable variations in inputs, transformations, and external factors" (Snee, 1993). In other words, the process is designed to accept uncontrollable variations and those variations will not affect end quality.

Primary techniques to create a robust work process include: simplifying the process; mistake-proofing the process; recognizing the lack of employee training; clearly communicating quality standards to all involved in the process including suppliers; recognizing external factors; and utilizing technology. But, by far the greatest asset in robust work processes is an individual's ingenuity and creativity. When empowered, people can examine the system or process and continuously improve it. A robust process will reduce variation and make aware the causes of variation so that they can be dealt with. By workers having a robust process, those things which management has absolutely no control over can be handled more easily because they will be special cases needing special actions (SNEE, 1993). This idea of variation in a robust system is closely tied to Deming's theory of common causes and special causes.

A common cause of variation in a work process is one which is inherently a flaw in the system. When there is variation, the chance of errors leading to rework exists. Even with the best intentions, a person cannot achieve quality if the system flaws do not allow for it. An example of a common cause would be voltage fluctuations in welding machinery. No matter how highly skilled the operator is, changes in voltage will reduce weld consistency. However, this variation can be examined and predicted by management using observational techniques and statistical monitoring. Once the sources of variation are identified, controls can be put into place to eliminate their effects, thereby increasing quality.

On the other hand, special causes are special cases which influence variation, but cannot be predicted or controlled. For example, an earthquake during production welding will impair quality. Since management has no control over special causes, their primary interest should be focused on the common causes. Eliminating common causes will help in creating a robust process. Common causes associated with people are improper or lack of training, equipment, direction, and/or motivation. These are independent variables and will be the focus of this research.

Training

There is a Japanese axiom that quality begins with training and ends with training (Imai, 1986). Training is an essential independent variable which affects quality. If a worker is not properly trained to perform a task correctly, the process is inherently flawed. Furthermore, even though a person has been properly trained, it does not automatically mean that the training experience will be used in the actual process. Joshua Hamond, president of the American Quality Foundation, concurs, "I would wager that 50% of the dollars spent on training are wasted" (Jacob, 1993).

Many training techniques exist and some are more effective than others. For example, Analog Devices uses just-in-time training. In 1991, it experimented by training half a group of 900 employees in a classroom and the other half as teams on the job. Fewer than 40% of the classroom group felt they had actually put their training to work, while 80% of the other group trained indicated they had (Jacob, 1993). This study suggests hands-on training may result in more immediate and complete understanding compared to what might be called academic training. Results can be attributed to many factors, but perhaps the most significant reason is that hands-on training involves workers in the task so that they must think through their actions and use reasoning to make decisions. In contrast, classroom techniques often do not involve the worker and tend to be challenging intellectually, but not practically. This conclusion reflects an underlying theme of TQM which states that workers want to have responsibility and make decisions.

In order to increase training effectiveness, a comprehensive behavioral task analysis can be used to identify the specific technical and non-technical behaviors needed to perform each job task or category successfully. Once behaviors are identified, the existing training programs can be evaluated and changed if necessary. Furthermore, human resource development can be used to recruit workers who will fit the organization's needs. For example, the job title of carpenter does not differentiate between skill levels and knowledge required for residential carpenters versus heavy construction carpenters. A journeyman level carpenter in heavy construction could specialize in concrete form construction, in which case he would lack the more general skills and knowledge necessary for custom home building.

Training employees to their highest capabilities is a major commitment for employers and often ignored by management. Management does not always see the importance of training as an investment and a resource. The first type of training focuses on general topics such as safety training, literacy training, or apprentice skills. Another type of training is skill specific. Sanders (1992) examined diverse companies in the construction industry and found:

> Some companies share that they were able to achieve very high welding standards because they had trained welders prior to undertaking a major welding project. The training was so successful that the number of defects was found to be far below the industry average, and in some instances no defects were found. One company described some principles they used in training, not so much to train for specific skills or general training, but to train the people so they are better prepared to implement a new idea. (Sanders, 1992, p. 372)

A knowledgeable trainer is almost as important as what is being taught and how it is being taught. Often training is done by other employees. If training is not organized and lacks structure, knowledge cannot be taught and information is lost. If, on the other hand, education is done by qualified employees within an organized structure, practical problems may be solved in the training process because the workers who actually know the processes are implementing the training. Another theory of training is the Learn Use Train Facilitate

Technique (LUTF) (Kessler, 1992). LUTF is a system in which workers study a principle and then apply it to a task. They then use the experience and knowledge gained to help others learn. The system is efficient because the number of people being educated increases exponentially.

In the construction industry a simple way to increase training effectiveness would be to remove the fear that workers have of admitting they do not know how to perform a task (Chase, 1992). While employers attribute poor productivity to a bad attitude or laziness, many motivated workers believe that if they tell a supervisor they do not know how to do a job they might be laid off and replaced by a more task-experienced worker. The result of this fear is workers teach themselves while performing tasks which greatly decreases quality. In addition, they become frustrated with their own substandard results and put the blame of rework on other factors rather than their lack of training.

Proactive training techniques can be task-specific and situational. Traditionally, training means to show a person how to perform a task. Situation training is educationally based and helps workers apply problem solving techniques in diverse situations. Workers are thereby trained to behave in a certain manner which can emphasize quality standards. Workers will add end-quality objectives to task accomplishment rather than focusing on task completion without regard for quality (Chase, 1992). This type of training must start with upper management and then be applied to other areas of business, it must be applied in the field and not just in the training room. Employees must get feedback from everyone including the customer if possible.

Under TQM, quality becomes everyone's responsibility and a training plan must be targeted at every level of the company. Often it is argued that the transient nature of the construction industry makes it impossible to implement TQM training principles. However, if training principles and quality awareness become industry standards, just as safety issues have, then quality awareness will no longer be company specific. The TQM principles a worker learns can be applicable as workers transfer from company to company. This prediction is supported by a recent survey of TQM implementation in more than 200 companies where it was found that skills in human interaction, leadership, and initiative are instrumental to the success of quality improvement (Dumas, 1989).

Equipment

Equipment are the physical tools needed to do the job. It is important to note that if a piece of machinery can perform the task, but the worker does not realize it, then there exists a training problem. In contrast, if the machinery is not working properly or cannot be used simultaneously to perform two tasks, then there is a equipment problem in the system.

When a worker does not have the proper tools to perform a task or if the tools are insufficient or broken there will be a reduction in quality. Deming (Walton, 1986) shows how a lack of equipment or improper equipment within a system will make quality outcomes near impossible. No matter how motivated or capable employees are, they can only produce to what the system allows. In other words, if the system has any inhibitors to necessary quality, such as improper equipment, a worker cannot easily attain it.

Motivation

Many times people incorrectly assume motivation is a personal trait; however, motivation is a state of being. A person may not be motivated to complete quality work in one area, but may be motivated in another. For example, a welder may not perform well out in the field, but her work improves in the shop because she prefers working in a stable environment. Motivation is the result of interaction between an individual and a situation. Motivation comes from an internal state that makes certain outcomes appear attractive. Attitudes create a drive within the person to satisfy particular goals to satisfy needs. In this way companies must make quality a desirable outcome.

Beyond giving incentives, there are inherent drives which give a person the propensity to work towards quality. Most motivational theories, from Maslow's Hierarchy of Needs to McClelland's Theory of Needs, report that humans naturally want to work to their capabilities and achieve their potential (Robbins, 1993). Self-actualization is of primary importance to humans and can be harnessed by employers. Moreover, people seek and accept responsibility for their work. While behavior theorists differ in the methods used to motivate people to attain goals, most agree that human beings naturally want to be motivated at work and that motivation is a determining factor in their success and contentment with a job.

Another way of thinking about employee performance is as a function of the interaction between ability and motivation. If either is inadequate then the performance will be negatively affected. Thus, one must consider an employee's ability (skills) in addition to motivation to accurately predict performance. Even with ability and motivation, an employee may not perform well if there are obstacles which constrain performance. In other words, the work environment, when ineffectively controlled by management, can inhibit quality performance.

Direction

The direction and energy in most organizational projects or group efforts is often dispersed and conflicting. Typically this situation occurs because people do not know why they are performing a task or how it fits into the organizational scheme (Merron, 1994). They have some sense of organizational strategy to achieve goals, but this strategy is rarely discussed. Sometimes workers know their purpose, but lack an understand of how others fit in, which leads to frustration and resentment. In contrast, when employees are committed and understand the organization, they are more productive and satisfied. Management's responsibility is to provide direction. One probable reason errors occur is that even though workers have the tools, skills, and predisposition to complete quality work, they receive different signals or instructions from management. Employees may be working extremely hard with little result if an organization is misaligned. These unclear signals can be of two types: either workers do not know what is required of them because there is no clearly defined objective, or management does not communicate requirements or changes them so often workers become confused.

A lack of direction will be a great hindrance to quality. One answer to this problem is to empower workers so that they understand overall objectives and make decisions. Empowerment on its simplest terms means to give power to someone. In a TQM culture, empowerment is providing adequate training with continuous process involvement tools and enough time to apply them. Simply telling people they are empowered without giving them the tools for change is ineffective (Heath, 1994).

Empowerment is to act in the best interest of the customer without needing management approval for all actions (Sanders, 1993). Employees can act on their natural initiative. Decisions are either pushed down to the lowest possible levels where the actual work takes place or employees below the level of decision maker are given the opportunity to influence decisions. This creates a situation where the people who have the greatest knowledge of a task can evaluate the immediate impact of a decision. Allowing them to make decisions increases their sense of importance and enables them to relate to the company's success. Furthermore, they assume responsibility and be more likely to act in the interest of all.

Empowerment requires trust between management and employees. Employees will realize they are an important part of the company and develop enthusiasm for company goals. Empowerment allows employees to direct themselves under the guidance of management. Leadership is still essential because workers must know what the goals and objectives are. It is imperative for leaders to realize that organizational culture can only be changed from the top. It is a leader's responsibility to communicate the company vision and purpose within a customer framework to all levels so that empowered employees will make correct decisions.

Beyond emphasizing quality in pre-construction activities, management must create on-site orientations for all employees. Federle (1993) proposes that quality will improve if there are on-site orientations for all employees to address issues which are not typical. Topics in addition to general quality expectation should include clear cut examples of what constitutes acceptable or unacceptable quality in all areas specific to the project. Discussing and producing a culture which avoids blame establishes a positive environment for quality. Further importance to on-site quality are weekly planning meetings with foremen, where equipment needs, coordination requirements, and possible problems can be discussed. The objective of all meetings is to create an advantageous quality culture which promotes cooperation and avoids blame. Included in management direction is providing workers with an attainable design.

Summary

While not much has specifically been researched regarding the most common hindrances to quality, there are major recurring themes in TQM which indicate areas to observe. Before one can understand these areas one must understand the need for quality and the influences on quality. Examining TQM, looking at productivity, and system approaches are ways to understand the influences on quality while focusing on customer needs. TQM tries to create the structure and environment which makes quality a likely outcome of processes by using incentives and empowerment. Furthermore, quality has a direct link to productivity. No process can obtain ideal productivity if its quality is lacking. This is mainly due to rework caused by errors and defects. Errors can be traced to four possible origins: lack of training, management direction, motivation, and equipment issues (Figure 1).

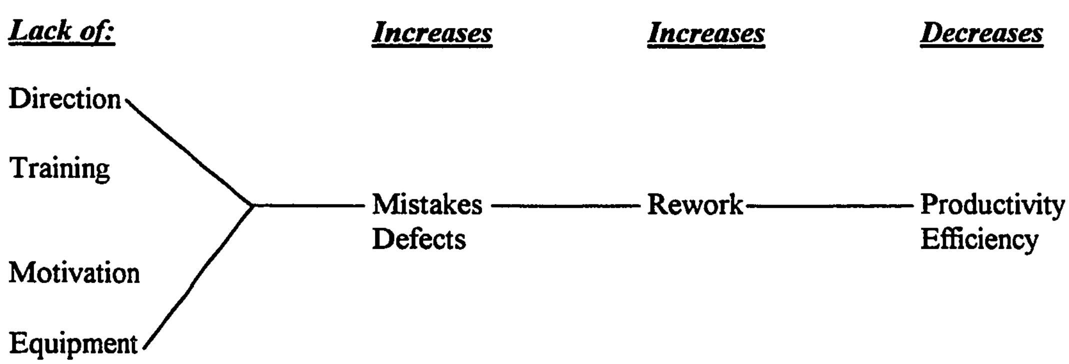

Figure 1

The Relationship Between Obstacles to Quality and Productivity

CHAPTER THREE

Methodology

Overview

This chapter describes the research method used to study the most common inhibitors to quality in the construction industry. The method used was survey research with a questionnaire distributed among building inspectors within the six county Bay Area in Northern California. This chapter describes the process implemented to achieve the research goal, including sample selection, instrumentation, and data analysis.

Research Design

Chapter 1 raised a number of issues surrounding obstacles to quality. Those issues were used to develop the following research questions.

1. What are the most common inhibitors to achieving quality in building construction?
2. What factors have the most influence on achieving quality?
3. Are there differences between different trades and their conformance to plans and specifications?

Very little information is available which would help answer these questions. While there are data from previous surveys, they have concentrated on quality attitudes and awareness (Kerr, 1989; Ryan, 1987). Therefore, it was necessary to identify the possible methods to obtain valid answers to the proposed research questions. The methods evaluated were quasi-experimental observations, interviews, and descriptive survey questionnaires.

Quasi-experimental observation would consist of designing an experiment in which workers would be observed in semi-controlled situation performing their work and then evaluated by conformance to quality requirements. There are many draw-backs to this method. First, this study is attempting to identify reoccurring inhibitors to quality which may or may not be consistently shown in experimentally controlled situations. Secondly, the cost and time constraints necessary to gain sufficient data would be beyond the resources of the researcher. Thirdly, biases from observers' and workers' knowledge of the study could lead to inaccurate results.

Personal interviews were also deemed inappropriate for this research since contacting the target populations would be very difficult due to geographical dispersion and availability of the sample for telephone or personal interviews. In addition, as with all interviews, there exists the possibility of bias from the interview which might influence responses to survey questions.

A self-administered mail questionnaire was chosen as the most reliable and efficient means of obtaining valid responses to the research questions. A general advantage of this method is that there is access to widely dispersed samples and samples which are difficult to reach by telephone or in person (Fowler, 1988). Furthermore, overall attitudes can be obtained based on respondents cumulative memory.

While there are many advantages to a self-report questionnaire, the disadvantages must also be discussed. As in any survey the respondents may have biases which do not reflect reality. For example, a respondent may answer a question with what is thought to be the correct answer, but is not backed by experience. However, similar drawbacks exist in other viable research methods. Special care must be taken when designing the questions so that they are not ambiguous or insignificant.

Instrumentation

As discussed above, the most efficient method to collect data was the descriptive survey method. A survey instrument, namely a questionnaire, was developed to help answer the research questions. The questionnaire addressed the issues of obstacles to quality in the construction industry. The questionnaire was designed with four-point Likert scale, ranking, multiple-choice, and open-ended questions. Many sections included the option of "Other" in order for subjects to write in a responses not anticipated by the researcher. Race, ethnicity, or sex were not relevant to the study; therefore, they were not included in the questionnaire.

In developing the instrument, three major factors were kept in mind: applicability, ease of response, and factual reporting. Special care was taken to safeguard that each question was applicable to the research questions. Potential questions were eliminated if they did not specifically relate to the research questions. Furthermore, questions were designed so that they could be answered easily and were not ambiguous. In addition, wording was as simple as possible and was kept at a high school graduate level. Lastly, respondents' factual reporting was tested in the design of the questionnaire so that internal validity could be estimated.

There are four basic reasons why respondents report events with less than perfect accuracy (Fowler, 1988). First, respondents may not have knowledge of the subject matter. To identify the respondents knowledge certain preliminary "demographic" type questions such as number of years experience and type of experience were included at the beginning of the questionnaire. Secondly, since this survey deals with general knowledge, memory decay or lack of recall can be a potential problem. Therefore, many similar questions were asked so that the respondents memory is stimulated to recall consistent observations over time. Thirdly, a person may not understand the question. As mentioned before the researcher tried to reduce ambiguity and use common language as tested in the pilot survey. Fourth, respondents may not want to report the answers. Since confidentiality was promised and the subject matter is not threatening, it is hard to conceive of a reason why respondents would not answer accurately and factually.

Target Population and Sampling Design

Since the research questions focus on worker quality, three alternative populations presented themselves for gathering data. Either workers could be sampled, managers (foremen or superintendents) could be sampled, or an unbiased third party could be used to gain insight into quality. Workers and managers were eliminated because they would be extremely biased and have, in most cases, limited ranges of experience in identifying quality issues. In addition, finding a randomly selected sample population would be extremely difficult. Thus it was determined, in order to gain information of workers and quality in the Bay Area it was necessary to obtain a unbiased observations.

While individuals and companies are ultimately legally responsible for all quality in the construction industry, inspectors are required to oversee general conformance to code, plan, and specification requirements. For this reason, inspectors were chosen as a sample population which would give comparatively unbiased opinions and a frame of reference which is based on very specific objectives. Inspectors, by their job definition, determine acceptable levels of quality. Their determinations are guided by general construction code regulations and specific job specifications.

Three main types of inspectors were used in the survey sample. The term Building Inspector refers to those inspector who are employed by city or county governments to inspect construction within the governments' jurisdiction. Building Inspectors usually inspect all areas of construction, however, their training or specialization may be divided into electrical, mechanical, plumbing, and general building inspections. Building Inspectors may observe work in progress or after completion during different phases of construction. An inspector who is qualified to approve all types of work is commonly referred to as a "Combination Inspector." Most jurisdictions require inspectors to pass a number of tests offered by the International Conference of Building Officials (I.C.B.O). These exams focus on code knowledge and plan reading ability.

The second type of inspector to be surveyed is referred to as a Deputy or Special Inspector. Special Inspectors are also offered I.C.B.O. exams in the areas of structural steel and welding, masonry, reinforced concrete, post-tensioned concrete, and fire-proofing. The Uniform Building Code, Section 306, requires special inspections during certain activities so as to ensure structural integrity (UBC, 1991). Special Inspectors are privately employed by owners of buildings being constructed. Special Inspectors are characteristically on the jobsite while work is in progress and have the opportunity to observe obstacles to achieving quality.

The last type of inspection category contains two types of inspectors: Office of the State Architect (OSA) and Office of Statewide Health Planning & Development (OSHPD). These private and publicly employed inspectors are also commonly referred to as Inspectors of Record (IOR). IORs are required by state law to be present during hospital and school construction, which are not covered by city or county inspectors. An IOR will pass a test given by OSA or OSHPD or both. OSA/OSHPD inspectors are similar to Combination Building Inspectors in that they cover large areas of construction work. However, IORs, like Special Inspectors, are generally required to be on the job-site continuously during construction.

By choosing Building Inspectors, Special Inspectors, and Inspectors of Record, the research population will represent all phases of construction in both the public and private sectors. Opinions from inspectors who observe work progress periodically and those who see it continually will be obtained. They will also give a broad base of experience with many types of trades. Most importantly their opinions are based upon conformance to specific objectives.

Questionnaire Summary

A copy of the survey and cover letter are available in Appendix A and B. Demographic information such as type of inspector and primary responsibilities were addressed in Questions 1 and 2 so that questionnaire results could be analyzed for different categories of workers. For example, Special Inspectors only inspect very specific types of structural construction, namely concrete, steel, and masonry. Therefore, Special Inspector's responses should only be applicable for those types of work. In contrast, Building and OSA/OSHPD inspectors typically inspect many different trades throughout all phases of construction. Thus their responses will tend to be more general to the construction industry.

Question 3, which identifies the types of construction inspected, helps qualify the final results. By selecting a broad sample population, the responses should reflect residential, commercial/industrial, and hospital/school construction. These natural divisions have their basis in common knowledge of the construction industry. While any type of inspector may work on all job sites, the usual specialization would be Building Inspectors working primarily in residential and commercial/industrial construction, OSA/OSHPD Inspectors working in hospitals and schools, and Special Inspectors working in all three divisions. It is important to note, however, that workers usually do not specialize, with the exception of residential, and can be inspected by all types of inspectors.

Since identifying obstacles to worker quality is the objective of this survey, knowing the average time spent on a job site per day is important (Question 4). In order for inspectors to know what obstacles exist they must devote time to watch workers perform tasks. Simply examining completed work may not provide clues to quality obstacles. The inspector population selected includes two types of inspectors, OSA/OSHPD and Special, that are required by code to be continuously present during actual construction. Question 4 allows the researcher to verify the respondents are qualified to comment on inhibitors to workers achieving quality. In addition, question 5 will give the researcher a idea of how many years experience are included in the respondents frame of reference.

Question 6 through 11 are designed to answer the research questions. Basically, five variables are used in each question. The variables are predetermined to be motivation, management direction, equipment, training, and design. Whether an inspector is asked to choose, rank, or scale an answer, these six questions focus on the obstacles to worker quality and factors necessary to achieve quality. By design the questions are similar, and perhaps redundant, since internal validity is necessary. Wording is changed in individual questions to reflect similar concepts. For example, motivation is also identified as enjoyment of work, caring about requirements, and pride in workmanship.

Question 12 shows any trends present based on inspectors' experience. This question can also be correlated with Question 5 which asks how many years experience a respondent has as an inspector. Furthermore, Question 13 allows the overall quality of trades' workmanship to be compared with each another. This question will differentiate between the trades and exhibit presumed commitment to quality in "educated" trades such as electricians and plumbers. Any differences in trades quality achievement are followed up by Question 14 which allows respondents to write in why some trades produce better quality compared to others. Furthermore, Question 15 relays the purpose of this study in the most simplest terms.

Coding

A coding system was used to analyze the questionnaire. Responses using a Likert-Scale response (Questions 6 and 9) were scaled from one to four with one being low. Interval level questions were scored with values provided by each subject. Thus, a subject answering ten to the number of years of experience was scored a ten. Number of years experience and number of hours spent per job-site were rounded, if necessary, to the nearest whole number. Nominally scaled variables, were kept as intact categories (inspector titles were coded with one of the possible three categories). Open ended questions were compiled, then categorized by groups of similar responses.

Pilot Survey

Prior to administering a pilot survey, the questionnaire was reviewed by Carol McCleland, Ph.D., for acceptable questionnaire format and design. A trail questionnaire was then distributed to nine inspectors (three Building, three Special, and three IOR Inspectors). Based on initial responses, several modifications were made to make the instrument relate more directly to the research questions. Furthermore, changes were made to enable ease of response. The survey was distributed with a cover letter explaining the intent of the questionnaire in hopes of raising the response rate. A postage paid return envelop was also included. Additionally, to further encourage a high response rate, the researcher offered to provide a copy of the compiled results.

Survey Administration

The research questionnaires were distributed predominantly in the Spring of 1995. In order for the researcher to obtain responses from Building Inspectors, a list of towns and cities contained within the six-county Bay Area was compiled. It is important to note that some smaller cities were eliminated from proposed reference points since they do not have building departments or they are included with the nearest population center. For example, Alviso is an annex of the City of San Jose. From a list of 58 cities, 9 within the County of Santa Clara were initially chosen to be included in this research. The remaining 18 cities outside of the County of Santa Clara were randomly selected to be included in the research, thereby including 27 of 58 cities. The sample contains a wide range of cities and counties with diverse populations and industries. Thus, this sample can be considered representative of the Bay Area. Appendix C lists those cities included in the study. Total individuals in the population is estimated at over 550. The resulting list exhibits a wide-cross section of very large industrial cities, such as Oakland, and smaller, less-developed areas, such as Morgan Hill. In addition, more affluent communities, namely Los Gatos and Saratoga, were also included. It is important to note that the City of San Francisco, with over 50 inspectors, would have been desirable to include in this research. However, it has a different personnel organization which would have made it impossible to gain access to all inspectors.

Two factors were examined to determining the number of cities to be selected. First, it can be assumed that the entire inspector population is largely homogeneous. In other words, all inspectors use the Uniform Building Code as a basis for inspection, as well as project specifications. In addition, there is no reason to believe that inspectors in one area might be exposed to a specific level of craftsmanship and types of workers which are not available in other areas. The worker population is largely mobile and varying degrees of workmanship are evident to all inspectors. Second, since the entire population of Special Inspectors and IORs can be estimated with sufficient accuracy, the researcher required that the number of sampled inspectors be near equal for each type of inspector. Had all building departments been selected for survey, their responses would have greatly out numbered those of Special Inspectors and IORs. The 24 building departments yielded 147 possible inspectors to be surveyed, of which 70 returned the survey (48.2%).

A list of approved Special Inspection companies in the Bay Area was obtained from the Special Inspection Committee of the International Conference of Building Officials. Per Uniform Building Code, all Special Inspectors must work for a testing laboratory; thus, it can be safely assumed that nearly all inspectors were included in the research. As with building departments, the inspection supervisor was contacted to gain approval for inclusion in the research, and questionnaires were then mailed. From 11 Special Inspection companies, 7 were randomly selected for inclusion in the research, with one not agreeing to the survey due to work load. Of a total population of an estimated 275 inspectors, 161 were given a survey with 59 returning it (36.6%).

A list of members of the American Construction Inspection Association's (ACIA) Northern California chapter was obtained and questionnaires were directly sent to all IORs. Furthermore, through industry research, other employed IORs who were not members of the ACIA were surveyed. However, similar to Building Inspectors, IORs make up a fairly homogenous population. Thus overall results should not be affected by exclusion of some inspectors. Of 112 IORs, 31 (27.6%) responded to the survey.

In addition five respondents marked their job classification as "Other." The other respondents worked mainly in inspection management for building and special inspectors, thus raising their individual percentages. Total usable responses were 165 out of 420 or 39.2%. Total responses were 171 (40.7%), however, four inspectors did not correctly follow directions, and two were returned for incorrect addresses.

Table 1

Survey Response Summary

Respondent Type	Sampled	Responded	Percent
Building Inspectors	147	70	48.2
Special Inspectors	151	59	36.6
Inspectors of Record	112	31	27.6
Other		5	
Totals	420	165	39.2

There is no clear reason why Special Inspectors and IORs did not respond in the same numbers as Building Inspectors. It can be speculated that Building Inspectors have sufficient office time available for responding to the survey, therefore, they were more likely to respond.

Analysis of Threats to Validity

Two areas appear to exist where critics may disagree with the study. The use of inspectors rather than workers is the first. But, as mentioned in Chapter One, inspectors provide presumed unbiased responses and have large exposure to many workers. The second criticism to the validity of this study is the same one used whenever a questionnaire process is involved to obtain data -- the questionnaire itself is a threat to the validity of the statistics and inferences drawn. Questionnaires may extract responses from an unintentional selected sample or bias could be present in the questions. As was mentioned before, care was taken to avoid any personal biases. In addition, the cover letter requesting help in the accumulation of information was screened to avoid any negative reaction to completion of the questionnaire.

Statistical Analysis

Since a descriptive survey was used , statistical analysis is limited to measures of central tendency in most cases. The measures of central tendency for nominally scaled variables are frequency and mean. In addition, the application of multiple analysis of variance procedures (ANOVA) was utilized to examine the statistical significance of data. Statistical significance of the results of data analysis was established at the $p < .05$ level.

CHAPTER FOUR

Results

Respondent Data

Of the 165 inspectors who correctly responded to the survey, 70 were Building Inspectors, 59 were Special Inspectors , 31 were IORs, and 5 classified themselves in the "Other" category. Of those who choose "Other" to describe their title, 3 wrote in responses relating to management positions in construction inspection. Four surveys are not included in the statistical analysis since the surveys were not completed fully or were not consistent with instructions.

When asked which types of work they inspect, inspectors chose from a list of eight common divisions of construction trades. Also included was the option to write in any type of work which was not specified in the list. Examples of work included in the "Other" category are fire-proofing and high strength bolting. Table 2 summarizes Question 2 results.

Table 2

Types of Work Inspected By Respondents

	Building Inspectors	Special Inspectors	IORs
Carpentry	92.9 %	23.7 %	90.3 %
Welding	21.4	72.9	51.6
Concrete	82.9	79.7	93.5
HVAC	84.3	3.4	96.8
Masonry	85.7	66.1	80.6
Electrical	85.7	8.5	100.0
Plumbing	85.7	1.7	96.8
Public Works	20.0	10.2	29.0
Other	18.6	17.0	12.9

Question 3 inquired what percentage of an inspector's time is spent on residential, commercial/industrial, or hospital/school job sites. The average time spent on residential projects is 33.29% while time spent on commercial/industrial and hospital/schools are 35.4% and 35.99% respectively for the total sample. Building Inspectors alone spend about 57.76% and 38.4% of their time on residential and commercial jobs respectively, with only 3.8% on hospital/school sites. In contrast IORs spend an average time of 83.06% on hospital and school job sites, .26% on residential, and 16.68% is concentrated on commercial/industrial construction. The majority of a Special Inspector's time is spent on commercial/industrial projects (70.32%) and hospital and schools follow next at 18.32%. Residential construction requires 9.59% on average of a Special Inspector's time.

The average time devoted to one job per day varies for continuous and periodic inspectors (Table 3). Periodic inspectors, such as building inspectors, spend a greater amount of time per jobsite compared to continuos inspectors.

Table 3

Mean Hours Spent per Jobsite

	M	SD
Building Inspectors	1.75	2.02
Special Inspectors	6.64	2.07
IORs	6.16	2.53
Total Sample	4.36	3.16

Question 5 relates to inspector experience and qualification in answering the survey. Although the mean number of years working as an inspector is 12.06, a standard deviation of 9.09 indicated the responses vary greatly (Table 4).

Table 4

Experience of Inspectors

Years	Frequency	Percent
1-5	42	25.5
6-10	47	28.5
11-15	31	18.8
16-20	18	11.0
21 +	25	15.2
Missing	2	1.0
Total	165	100.0

Question 6 asks a number of questions relating to workers' general environment and preparedness. On a scale from one to four (1 = Disagree, 4 = Agree) inspectors were asked, based on their observations, under what conditions work is best performed (Table 5). It is apparent that accessibility of plans and specifications and worker responsibility have a strong positive impact on achieving quality.

Table 5

Mean Ranking Scores of Question 6

Work is best performed when:	M	SD
Plans and specifications are easily assessable	3.09	.88
Workers have high levels of responsibility	2.92	.76
Workers are strictly supervised	2.76	.89
Work is self-inspected	1.96	.96

NOTE: For means: 1= Disagreement, 4 = Agreement

Question 7 resulted in training as the most important item assisting workers in meeting code requirements. Following training is having direction by management, proper tools and equipment, sufficient time and work enjoyment. There is no difference between responses of the three inspector classifications individually and the sample as a whole.

Table 6

Ranking of Items Assisting Workers to Attain Code Requirements

Rank	Total Sample
First	Training
Second	Management
Third	Tools/Equip.
Fourth	Time
Fifth	Enjoyment

Note: Ranking from First (Most Important) to Fifth (Least Important)

Question 8 is the most direct question in the survey and answers the first research question. When asked to choose the biggest obstacle workers face when meeting plan and code requirements, not knowing how (insufficient training) and not having management direction acquired 83.6% of all responses. By examining a cross tabulation of type of inspectors (Question 1) and Question 8 results, it is discovered that Special Inspectors and IORs chose management direction over training as the biggest obstacle to quality. In contrast, Building Inspectors selected training as the biggest obstacle at 64.3% (Table 7).

Table 7

Question 8 Results for all Respondents

	Frequency	Percent
Training	72	43.6
Direction	66	40.0
Equipment	2	1.2
Design	2	1.2
Motivation	12	7.3
Other	10	6.1

In order to determine if an association exists between inspection experience and responses to Question 8, a chi-square statistic was calculated, and it was found that no statistically significant relationship exists. There was, however, a difference in the frequencies of responses by inspector type (Table 8).

Table 8

Cross tabulation of Questions 1 and 8. Selection of the Biggest Obstacle in Meeting Requirements by Percentages of Responses

	Training	Direction	Equipment	Design	Motivation	Other
Building	64.3	22.9	1.4	1.4	7.1	2.9
Special	25.9	48.3	1.7	1.7	8.6	13.8
IOR	32.3	61.3			6.4	
Other	40.0	60.0				

On a scale of one (strongly disagree) to four (strongly agree) subjects were asked to react to eight statements relating to quality (Question 9). The eight sub-questions contained in Question 9 can be divided into five categories: equipment; time constraints; motivation; code requirements; and design attainability. Question 9A deals with equipment availability and is consistent with Question 8 results which indicate workers have proper equipment and tools to complete tasks. A 83.7% majority disagreed that workers never have the right tools to do their job (M = 1.91, SD = .69). Question 9b and 9f relate to management's emphasis on production and not quality. A mean of 3.11 (SD =.79) illustrates that workers do not spend enough time reading plans. Furthermore, a mean of 3.02 (SD = .75) shows that workers are more concerned with time in comparison to quality.

Questions 9c and 9g deal with worker motivation. When asked if workers are not motivated (Question 9c) a mean of 2.54 (SD = .69) indicated inspectors somewhat disagree with the statement. As suggested by question 9g (M = 2.37, SD = .81) there is no strong agreement or disagreement that workers take pride in their work.

Questions 9d and 9h looked at the influence code requirements could have on quality. Some 76.9% of respondents agreed that workers are ignorant of code requirements, which is a training issue, and 57% of the respondents disagreed that code requirements are too complicated. Question 9e asked if designs are impossible to achieve. A mean of 2.3 (SD = .80) illustrates inspectors somewhat disagree.

Table 9

Opinions Regarding Equipment, Time Constraints, Motivation, Code Requirements, and Design Attainability

	Agree	Disagree
9a. Workers never have the right tools to do their job	15.8%	84.1%
9b. Workers do not spend enough time reading plans	79.8	19.1
9f. Workers are more concerned about time than quality	76.7	23.3
9c. Workers are not motivated	54.3	45.7
9g. Workers have no pride in their work	42.3	57.7
9d. Workers are ignorant of code requirements	77.5	22.5
9h. Code requirements have become too complicated	42.9	57.0
9e. Designs are often impossible to achieve	40.3	59.8

Note: 1 case (.6%) of 165 did not respond to Question 9

Question 10 asked subjects to rank from most important to least important what assists workers in "doing a better job" and reducing rework. Choices available were improved tools and equipment, simplified plans and specifications (Design), having someone specify what is required before work starts (Management), caring more about workmanship (Pride), and better training.

Table 10

Question 10. Influences on Quality Attainment

Rank	Total Sample	Building Inspectors	Special Inspectors	IORs
First	Management	Training	Management	Management
Second	Training	Management	Training	Training
Third	Pride	Pride	Tools/Equip.	Pride
Fourth	Tools/Equip.	Tools/Equip.	Pride	Design
Fifth	Design	Design	Design	Tools/Equip.

Note: Ranking from First (Most Important) to Fifth (Least Important)

Question 11 required subjects to rank those variables which have the greatest influence on completing a task correctly. Management and training consistently ranked first or second (Table 11).

Table 11

Ranking of Reasons Why a Task is Completed Correctly

Rank	Total Sample	Building Inspectors	Special Inspectors	IORs
First	Management	Training	Management	Management
Second	Training	Management	Training	Training
Third	Motivation	Motivation	Tools/Equip.	Tools/Equip.
Fourth	Tools/Equip.	Tools/Equip.	Motivation	Design
Fifth	Design	Design	Design	Motivation

Note: Ranking from First (Most Important) to Fifth (Least Important)

Question 12 shows that worker quality has remained about the same. Quality stability is true for the total sample as well as individual inspector categories. Only 11.1% of respondents indicated that quality has increased greatly, and 4.9% indicated quality has decreased greatly; the remaining frequencies are in the middle. In order to determine if there exists a correlation between the number of years a respondent has worked as an inspector and how worker quality has changed, a chi-squared statistic was calculated. Yet, it was found that no statistically significant relationship occurs.

Question 13 rates trades in overall conformance to plan and code requirements. Respondents were asked to only answer for those trade that they inspect (Table 12).

Table 12

Rating of Trades' Quality Conformance

Trade	Responding	M	SD
Electricians	118	3.07	.61
Welders	116	2.94	.66
HVAC	107	2.68	.65
Concrete	145	2.62	.72
Plumber	109	2.61	.58
Masons	133	2.52	.68
Carpenter	130	2.44	.73
Public works	60	2.38	.80

NOTE. 1 = Poor; 2 = Fair; 3 = Good; 4 = Excellent.

Electricians show the greatest conformance to code with a combined good to excellent score of 86.5%. The second highest rating is that of welders at 76.7% for good to excellent. Mechanical/HVAC has a good rating of 61.7%, second only to electricians. Plumbers and mechanical, carpentry, masons, and concrete workers all scored in the good to fair range. Public works has the poorest rating (55%) in the substandard range (M= 2.38, SD = .8). The high standard deviation can be traced to a low response rate of 60 valid cases.

Table 13

Trades' Conformance To Quality Standards

	Poor	Fair	Good	Excellent
Electricians	.8%	12.7%	65.3%	21.2%
Welders	.9	22.4	58.6	18.1
HVAC	4.7	28.0	61.7	5.6
Concrete	6.9	31.0	55.2	6.9
Plumbers	1.8	38.5	56.9	2.8
Masons	6.0	40.6	48.9	4.5
Carpenter	12.3	33.1	53.1	1.5
Public Works	13.3	41.7	38.3	6.7

One way Analysis of Variance (ANOVAs) were computed for each sub-category in Question 13 and for inspector classifications. Among the eight tests, three were found to be statistically significant; indicating that the differences in responses did not occur by chance (Table 14).

Table 14

One Way ANOVAs for Worker Type and Inspector Classifications

	Degrees of Freedom	F Ratio
Electricians	113	2.375
Welders	111	.5570
HVAC	102	.3162
Concrete	140	3.981*
Plumbers	104	2.518
Masons	128	5.929*
Carpenter	125	.7772
Public Works	55	3.453*

* = Statistically Significant ($p < .05$)

For concrete workers, Special Inspectors (M = 2.789) gave significantly higher scores when compared to IORs (M = 2.321). Building Inspectors' scored (M = 2.717) significantly higher than both Special Inspectors' (M = 2.349) and IORs' (M = 2.269) when evaluating masons. Lastly, when evaluating public works conformance to code, Building Inspectors (M = 2.65) rated higher than Special Inspectors at M = 2.0.

Of the 165 respondents, 134 and 150 wrote comments for Questions 14 and 15 respectively. For both items training was indicated as an important positive influence on quality.

CHAPTER FIVE

Discussion

Overview

While the research instrument's primary objective was to answer the three research questions, a significant amount of information regarding respondent background and influences on quality was also obtained. The following discussion of these items exhibits validity of the sample instrument and its results.

Respondent Data

A number of questions are useful in verifying the consistency of respondents' answers. For example, it was assumed in research design that Building Inspectors and IORs deal with nearly all of the types of work listed in Question 2, with emphasis on carpentry, concrete, HVAC, masonry, electrical, and plumbing. After the researcher analyzed the type of inspector in Question 1 and selections in Question 2, this assumption proved to be true. Moreover, Special Inspectors are expected by code regulations to inspect predominantly in the areas of concrete, welding, and masonry. Due to expanded job requirements in the marketplace, Special Inspectors may also have other areas of responsibility, such as carpentry, which impact their schedules.

It is apparent that the respondent data is sufficient and relevant to apply results to all types of construction. When asked to give the amount of time spent on residential, commercial, or hospital/school job sites, answers were consistent with the researcher's predictions. Since IORs are required on all hospital and school construction, an average time spent on hospital and school job sites of 83.06% is not surprising. It is, however, curious that 16.68% of their time is spent on commercial/industrial job sites. Although Special Inspectors may be required on some types of residential construction, the majority of a Special Inspector's time is spent on commercial/industrial projects (70.32%). The researcher had no true prediction of the amount of time Building Inspectors devote to residential construction. Since this study is required to be applicable to all types of construction workers, discovering the amount of time Building Inspectors spend on residential jobs can give significant information of differences between residential construction workers and commercial if they exist. Building Inspectors allow 57.76% and 38.4% of their time for residential and commercial/industrial jobs respectively.

The average time spent on one job per day is 4.36 hours. Special Inspectors and IORs commit a little over six hours per job, which is expected since they are required to inspect continuously. Building Inspectors, on the other hand, spend fewer than two hours per day on each job, including travel time, with many devoting less than an hour on each. Significant differences in responses between full-time inspectors and periodic inspectors can, perhaps, be traced to the average amount of time spent per job. In other words, a Building Inspector who spends less than one hour evaluating workers may not see underlying causes of poor quality performance. Low quality may automatically be attributed to worker training and not other less obvious factors.

All surveys were included regardless of individuals' experience working as an inspector. Ranging from one to forty-one years, it appears the sample population has appropriate knowledge and experience to respond adequately to the survey. While years working do not necessarily equate with experience or knowledge, it can be argued a correlation exists.

Worker Environment and Preparedness

Question 6 asked a number of questions relating to workers' general environment and preparedness. On a four point scale, 74.6% of respondents agree that plans are accessible to workers with a mean score of 3.09. In construction, the plans are arguably the most important tool in obtaining quality results. Since a premise of this study is that achieving quality can be equated to meeting plan and specification requirements, the availability of plans to workers in addition to supervisors is very important. By agreeing that plans are available it is shown that ignorance of requirements due to unavailability can be eliminated as a cause of substandard quality.

However, as will be discussed later, simply because plans are available, it does not mean that they are utilized. It is also important to note that some respondents commented that plans are available to supervisors, but not the actual workers who complete the tasks. "Most workers below the level of superintendent or foreman, with the exception of electricians, plumbers, HVAC, and some carpenters have little or no direct contact with plans and specifications and rely on the foreman to direct their actions. A lack of or unclear communication of job requirements results in poor quality," noted a Building Inspector. The implication of this statement is management must have a more controlling influence to ensure information contained in plans is communicated correctly and sufficiently throughout an organizational structure. The opposite theory to hierarchical communication of requirements would be if workers on all levels can reference plans, they will have more individual responsibility to meet requirements.

Personnel being strictly supervised can be viewed both positively and negatively. Deming's TQM philosophy suggests workers should not be strictly supervised in the sense of having all actions directed by management; this leads to inflexibility and low motivation. While 60.4% of the inspectors agree workers are strictly supervised, it is not an overwhelming majority. There is a possible indication of controlling management.

Obviously when work is self-inspected the worker must know what the requirements are. Having work being self-inspected is a very complicated process which if implemented correctly will reduce rework and the need for strict quality control. Self-inspection is an indication of quality emphasis and worker responsibility. Of the 70.8% of respondents who disagree that work is self-inspected, 40.4% strongly disagree; indicating there is a need for not only improved quality control, but also quality assurance.

Workers having responsibility is a key concept necessary when implementing Total Quality Management programs. The respondents agree (73.3%) that workers should have responsibility. Thus, workers lacking responsibility can also be eliminated as a reason for low quality.

Obstacles to Quality

When asked what is the most important item which assists a worker in meeting code requirements, the overwhelming answer is training. Following training is having management direction, tools and equipment, adequate completion time and work enjoyment. When inquiring how workers can do a better job and reduce rework, management ranks first followed closely by training. Insufficient tools or equipment issues are insignificant compared other alternatives.

Question 8 is a key question to this study. Given a list of five variables, respondents were asked to choose the most important obstacle to meeting project requirements. Not having proper equipment, being asked to do something impossible, or not being motivated ranked extremely low. In fact, it is apparent that workers do generally have correct tools and equipment. This is probably in great contrast to manufacturing situation in which proper equipment has greater influence on quality. In construction, however, not knowing how to do a job is the number one obstacle to meeting requirements, being chosen almost 44% of the time, followed closely by the boss not telling what is required (40.0%).

Questions 10, and 11 were ranking questions designed to complement Question 8 by examining common obstacles to quality from different perspectives. Question 10 relates to how one could improve quality and Question 11 asks specifically why quality is achieved. The results of these questions are consistent with Question 8's multiple choice responses. Once again, Building Inspectors see training as having more influence over management direction, while Special Inspectors and IORs rank management direction higher.

There is a difference between how continuous and periodic inspectors respond. Building Inspector chose training as the most important obstacle in meeting quality requirements (64.3%). In contrast IORs and Special Inspectors who spend more time on the job witnessing progress selected management.

External Factors

Since the code requirements are the only stable quality standards which remain the same from job to job, knowledge of the code is an important prerequisite to achieving quality. If code requirements are extremely complicated it may be impossible for an average worker to follow them, thus greatly affecting quality output. Yet, 57.0% of respondents disagree that code requirements are too complicated. There seems to be no strong indication that the code is too complicated and cannot be understood with minimal education.

Having proper designs is necessary for project quality. If an architect or engineer creates designs which are extremely difficult or impossible to achieve, then regardless of workers' training or resources available, quality will suffer since, by definition, quality is conformance to requirements. A mean of 2.3 (SD =.80) for Question 9e shows that inspectors somewhat disagree designs are impossible to achieve. Thus designs in general are attainable and do not have great influence on lacking quality.

Similarly, motivation and equipment issues tend to be sufficient for quality outputs. As noted in other survey questions and verified by Question 9A, equipment and tools necessary to complete tasks are available to workers. In addition, workers may not take great pride in their work or enjoy it, but this does not seem to be an important limiting factor in achieving quality.

Perhaps one of the most important factors which influences quality, which the researcher did not give prior emphasis, is the effect of time constraints on workers. Of all respondents, 76.7% believe that workers are more concerned about time rather than quality. Even though this factor was only included in one sub-question of the survey, it was a frequent written response on suggestions for improving quality. Ultimately, time constraints are management issues. From a TQM perspective, workers should be allowed adequate time to correctly completed tasks. Limiting time becomes counter-productive since it may increase rework.

Differences Between Trades

Electricians show the greatest conformance to code with a mean positive score of 3.07 (SD = .61). The second highest rating is that of welders (M=2.94, SD = .66). Surprisingly welders score higher than other trades such as plumbers which seem to have the reputation of being more educated. Perhaps an underlying reason can be attributed to welders practicing more of a craft where code requirements are minimal compared to plumbing, electrical, and HVAC. Code pages devoted to plumbing, electrical, and HVAC far out number those devoted to other types of construction, therefore one can speculate that more formal trade education is required for these worker classifications.

When examined using mean scores and individual percentages Question 12 exhibits what is expected: those trades which are seen as more technical and require increased education and knowledge rate higher than those which require skill (i.e., dexterity, in the case of welders). As one written response clarifies, "Electricians are best noted for their work quality due to the dedication to the apprenticeship program."

Research Question Summary

This study focuses on the factors which limit quality by specifically identifying some of the most common inhibiting factors to quality in the construction industry. From an inspector's perspective, obstacles towards quality were identified and ranked. Quality was defined from a commonly accepted definition of conformance to plans, specifications, and code requirements.

In response to the first research question (what are the most common inhibitors to achieving quality in building construction?), the overwhelming majority of responses consistently place a lack of training and management direction as the two most common inhibitors to quality. Similar results were obtained for the second research question, which sought which factors have the most influence on achieving quality. It is important to note that for the total sample, training is the single most important factor impacting workers' quality. However, continuous inspectors identify management direction above training as a more common influence on quality, while Building Inspectors choose training over management.

The last research question asked if there are differences between different trades and their conformance to plans and specifications. The data suggest that some of the more technical and educated trades, such as electricians, have greater conformance to quality requirements. There is, however, no clear division or pattern among trades which led to definitive reasons surrounding differences.

Recommendations

Many write-in responses in the comment section of the questionnaire suggested there exists a current emphasis on time constraints due to competitive bidding which adversely affects quality. One IOR respondent with over twenty years experience expressed how quality is directly related to costs:

> The owner often hires a design professional as cheaply as possible. The designer doesn't have the money in his contract to do a detailed set of contract documents. . . Details get left out or skimmed over. . .The owner then hires a low bidder to do the work. The contractor bids the work as cheaply as possible. He often doesn't have the money in the contract to do a quality project. If a contractor anticipates all the requirements and problems he probably won't get the job.

This phenomenon is not limited to the construction industry. Workers are being pushed to complete tasks in reduced amounts of time which does not always allow for quality assurance. The theory behind a time emphasis can be traced to the belief that material and equipment costs are fixed while labor is not. Thus, reducing labor is a significant alternative when reducing total costs and increasing profits. In contrast, Total Quality Management proposes that focusing on quality is a superior technique to increase productivity. The rational behind TQM is unless quality is emphasized, rework will result. In construction, as with any other industry, rework destroys productivity and increases costs. Therefore, rather than time, management should attempt to emphasize productivity which includes quality and efficiency. By focusing on quality, time and costs will be reduced due to efficiency.

Since quality management must focuses on the process as well as outputs, a systems approach to process productivity is necessary. On a job site, the system consists of workers, tools, management direction, an attainable design, and many more items. Management's responsibility is to create an environment where all can be utilized in the most efficient manner. This research found that while some factors, such as equipment and design, are important parts of a system, they usually are adequate and do not adversely affect quality. In contrast, training and proper management direction appear to often be inadequate and should receive more attention. Management should not, however, randomly change systems. They should first examine root causes of low quality of productivity.

Management should also take responsibility for quality issues. Management must realize that special training is often needed due to the increase of technology in the construction industry. Firms elect to use new products which workers may not be familiar with. In addition, it is ultimately a contractors responsibility to create a system which has all the elements necessary to achieve quality. Management must work with trades to guarantee basic training is provided as well as sufficient motivation. Human resource policies can also be implemented to select workers who create a commitment to quality and pride in workmanship.

Workers should take responsibility for their education, knowledge, and skill levels. The survey indicated there appears to be a difference between union and nonunion workers. As one anonymous respondent wrote: "Union trades tend to be extremely more quality oriented and more highly trained vs. non-union sectors which typically have lower paid poorly trained workers and equipment." Yet it is important to note that many non-union workers have union training. One inspector suggested workers obtaining a trade competency card similar to welder certifications will allow for easier identification of skills before a task is started.

If union and non-union worker divisions continue to exist, the responsibility of worker training may be shifted. Unions will be responsible for training their workers, while management will have to provide more basic training and supervision of non-union employees. Ultimately, however, workers must feel they are responsible for their own training. Workers must create a balance between continued education and experience to give necessary knowledge and skill levels. Strong motivation may cause one to get training and education. Since code requirements do not change from job to job, trade training should emphasize codes.

Implications for Future Research

Future research can be conducted in four areas to strengthen this study. First, the geographical distribution of respondents can be increased to make the results of this study applicable to workers throughout California and beyond. Secondly, the survey can be given to management and workers to examine whether or not their responses will be different from those obtained from inspectors. Inspectors were chosen for this research since they are assumed to be unbiased. Even with their biases, management and workers can provide very important input into the obstacles to quality in the construction industry. Third, it would prove useful to compare the results of this survey, focusing on the construction industry, with other manufacturing industries. Since Total Quality Management can be applied to every industry, any differences between industries in their perceptions about quality inhibitors would be interesting. Lastly, the differences between commercial and residential construction can be more fully examined.

Summary Recommendations

In order to reduce rework by emphasizing productivity and quality issues there are a number of basic recommendations which must be continually examined in relation to specific tasks.

- Management must take responsibility for quality issues. This includes providing achievable designs, equipment, motivation and special training.
- A system view of processes should be adopted.
- Workers must take responsibility for their individual training and continual education.
- There should be less emphasis on production time and more emphasis on quality. By emphasizing quality, rework is reduced thereby increasing efficiency which is positively related to productivity.
- Workers should be empowered to complete tasks without fear from management or barriers. Encouraging questions when directions are not clear, knowing before hand what is expected, and having the correct tools and equipment are important steps to achieving quality.
- Stop depending on quality control inspections. While inspectors are necessary to insure public safety and contract enforcement for owners, they should not be the only ones concerned with quality. Every worker has quality responsibilities and should be given that responsibility by management.
- Increase communication between design professionals, management, foremen, workers and inspectors.
- Enforcement of requirements should be standardized.

By following the above recommendations, obstacles to quality can be removed to benefit all involved. Using TQM principles allows for many advantages: workers have greater pride in workmanship and job satisfaction; profitability through efficiency increases; and final product can be achieved in a timely manner. However, just as construction is completed in small segments, each building upon the last, eliminating the obstacles to worker quality also requires incremental advancements. Quality improvement must be a continual process, and positive results are not always immediate. Yet focusing on quality will help ensure worker motivation, effective use of resources and, most importantly, public safety.

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APPENDIX A

Survey Cover Letter

SJSU SAN JOSE STATE UNIVERSITY

A campus of The California State University

Department of Interdisciplinary Studies - Quality Assurance Engineering

Office of the Academic Vice President • *Associate Academic Vice President* • *Graduate Studies and Research*
One Washington Square • San José, California 95192-0025 • 408/924-2480

Dear Inspector:

You have been selected to take part in a university graduate research project. Attached to this letter is a questionnaire which will only take a few moments of your time to complete. The information obtained from you and other respondents will be used to gain insight into current construction practices and will be submitted for publication. In addition, your knowledge will assist in understanding and increasing overall construction industry quality. To show our gratitude for you taking part in this survey, a summary of the final results and commentary will be available to any respondent who requests it.

You should understand that your participation is voluntary and will not affect your relationship with San Jose State University (or other participating institutions). Your answers to the following 15 questions will be completely confidential. Please answer all questions truthfully, and if you have any comments, write them down next to individual questions or at the end of the questionnaire. After completing the questionnaire, return it in the included self addressed-stamped envelope.

If you have any questions about this study, I will be happy to talk with you. I can be reached at (408) 266-9877. If you have any questions or complaints about research subject's rights, please contact Serena Stanford, Ph.D., Associate Vice President for Graduate Studies and Research, at (408) 924-2480. Thank you for your help.

Sincerely,

Timothy R. Kirsch
Graduate Researcher

APPENDIX B

Questionnaire

Please answer all the questions truthfully and remember that all your answers are confidential. If you have any questions or comments please feel free to write them down next to the questions or at the end of the questionnaire.

Name (optional) ______________________________

1. The job classification which best describes my work is: *(choose one)*
   ___ Building Inspector
   ___ Special Inspector
   ___ OSA/OSHPD Inspector
   ___ Other______________________________

2. I primarily inspect the following types of work: *(pick as apply)*

___ Carpentry	___ Welding	___ Concrete	___ Mechanical/HVAC
___ Masonry	___ Electrical	___ Plumbing	___ Public Works

   Other______________________________

3. What percentage of your time is spent on:
   Residential job sites ....___%
   Commercial/ Industrial job sites..........___%
   Hospital/ School job sites..................___%
   Other ______________________________

4. The average time spent on **one** job site **per day** is ___ hours.

5. I have worked as an inspector for ___ years.

6. Read the following statements an circle the degree to which you agree or disagree.
   4=strongly agree, 3=somewhat agree, 2=somewhat disagree, 1=strongly disagree
   From your observations work is best performed when:

	Agree		Disagree	
The plans and specifications are easily accessible to most workers	4	3	2	1
Workers have high levels of responsibility	4	3	2	1
Workers are strictly supervised	4	3	2	1
Work is self inspected	4	3	2	1

7. The following statements describe some things that help workers to meet code and plan requirements. Rank them according to importance from 1 *(most important)* to 5 *(least important)*.
   ___ Being trained
   ___ Having the right tools and equipment
   ___ Having direction from management
   ___ Having enough time to do a task
   ___ Enjoying their work
   ___ Other______________________________

8. In your opinion, what is the **biggest** obstacle workers face meeting plan and code requirements? *(choose one)*
   ___ They don't know how
   ___ Their boss doesn't tell them what is required
   ___ They don't have the right tools or equipment
   ___ They are asked to do the impossible
   ___ They do not care about meeting requirements
   ___ Other ____

9. Read the following statements an circle the degree to which you agree or disagree.
   4=strongly agree, 3=somewhat agree, 2=somewhat disagree, 1=strongly disagree

	Agree			Disagree
Workers never have the right tools to do their job	4	3	2	1
Workers do not spend enough time reading plans	4	3	2	1
Workers are not motivated	4	3	2	1
Workers are ignorant of code requirements	4	3	2	1
Designs are often impossible to achieve	4	3	2	1
Workers are more concerned about time than quality	4	3	2	1
Workers have no pride in their work	4	3	2	1
Code requirements have become too complicated	4	3	2	1

10. Workers would do a better job if: *(rank from 1 to 5, with 1 being most important and 5 being least important))*
   ___ They had better tools and equipment
   ___ They had better training
   ___ Someone would tell them what is required before work is started
   ___ They cared more about their workmanship
   ___ Plans and specifications were simpler
   ___ Other____

11. When a task is completed correctly, it is because: *(rank from 1 to 5, with 1 being most important and 5 being least important)*
   ___ The design is attainable
   ___ Workers have the proper tools and materials
   ___ Superintendents or foremen explain what is required before work begins
   ___ Workers are motivated
   ___ Workers have the proper skills to perform their tasks
   ___ Other____

12. Since first working as an inspector to the present time, worker quality (i.e. meeting specifications and code) has...*(Choose One)*
    ___ Increased greatly
    ___ Slightly increased
    ___ Remained about the same
    ___ Slightly decreased
    ___ Decreased greatly

13. How would you rate the following trades in overall conformance to plans and code requirements? *(Circle answers for only those trades that you inspect)*

Electricians	Poor	Fair	Good	Excellent
Carpenters	Poor	Fair	Good	Excellent
Plumbers	Poor	Fair	Good	Excellent
Masons	Poor	Fair	Good	Excellent
Welders	Poor	Fair	Good	Excellent
Concrete workers	Poor	Fair	Good	Excellent
Mechanical/HVAC	Poor	Fair	Good	Excellent
Public Works	Poor	Fair	Good	Excellent

14. Overall, why do you think some trades produce quality (i.e. meet plans and specifications) compared to other trades?

____
____
____
____
____

15. How can workers be helped to achieve better quality?

____
____
____
____
____

16. Comments

____
____
____
____

Thank you for taking part in this survey. If you have any further questions or comments please feel free to contact the researcher at (408)266-9877 any weekday during regular business hours.

APPENDIX C

Geographical Distribution of the Bay Area

GEOGRAPHICAL DIVISION OF THE BAY AREA

San Francisco County
San Francisco

San Mateo County
Atherton
Belmont*
Burlingame*
Colma/Brisbane
Daly City
Foster City*
Half Moon Bay
Hillsburough
Menlo Park*
Millbrae*
Redwood City*
San Bruno
San Carlos
San Mateo
Woodside

Santa Clara County
Campbell*
County of Santa Clara*
Cupertino*
Gilroy*
Los Altos*
Los Altos Hills*
Los Gatos*
Milpitas*
Monte Sereno*
Morgan Hill*
Mountain View*
Palo Alto*
San Jose*
Santa Clara*
Saratoga*
Sunnyvale*

Alameda County
Alameda
Albany
Berkley
Dublin
Fremont*
Hayward
Livermore
Oakland*
Pleasanton
San Leandro
Union City

Contra Costs County
Alamo/Danville
Antioch
Brentwood
Concord*
El Cerrito
Lafayettte
Martinez
Moraga
Orinda
Pinole
Pittsburg
Pleasant Hill
Richmond*
San Ramone
Walnut Creek*

Note: Cities selected for research are indicated by *

APPENDIX D

Research Approval for the Protection of Human Subjects

SJSU SAN JOSE STATE UNIVERSITY

A campus of The California State University

Office of the Academic Vice President • Associate Academic Vice President • Graduate Studies and Research
One Washington Square • San José, California 95192-0025 • 408/924-2480

TO: Timothy Kirsh
1482 Cherry Garden Lane
San Jose, CA 95125

FROM: Serena W. Stanford Serena W. Stanford
AAVP, Graduate Studies & Research

DATE: February 8, 1995

The Human Subjects-Institutional Review Board has approved your request to use humans subjects in the study entitled:

"Inhibitors to Quality in the Construction Industry"

This approval is contingent upon the subjects participating in your research project being approriately protected from risk. This includes the protection of the anonymity of the subjects' identity when they participate in your research project, and with regard to any and all data that may be collected from the subjects. The Board's approval includes continued monitoring of your research by the Board to assure that the subjects are being adequately and properly protected from such risks. If at any time a subject becomes injured or complains of injury, you must notify Dr. Serena Stanford immediately. Injury includes but is not limited to bodily harm, psychological trauma and release of potentially damaging personal information.

Please also be advised that each subject needs to be fully informed and aware that their pariticpation in your research project is voluntary, and that he or she may withdraw from the project at any time. Further, a subject's participation, refusal to participate, or withdrawal, will not affect any services the subject is receiving or will receive at the institution in which the research is being conducted.

If you have any questions, please contact me at (408) 924-2480.